NOTES TOWARDS REDEFINING THE IMPACT OF NEW TECHNOLOGY ON PEOPLE AND THE WORKPLACE

by Hazel Kerwood, P. Eng.

Ontario
Ministry of
Labour

Ontario
Quality of
Working Life
Centre

NOTES TOWARDS REDEFINING THE IMPACT OF NEW TECHNOLOGY ON PEOPLE AND THE WORKPLACE

by Hazel Kerwood, P. Eng.

NOTES TOWARDS REDEFINING
THE IMPACT OF NEW TECHNOLOGY ON PEOPLE AND THE WORKPLACE

by
Hazel Kerwood, P. Eng.

NOTES TOWARDS REDEFINING THE IMPACT OF NEW TECHNOLOGY ON PEOPLE AND THE WORKPLACE

1.0. Introduction

New technology is being embraced by both business and government as the saviour of future competitiveness for Canadian business. However, even though technology is a critical factor, new technology is, as was old technology, merely a tool. It, therefore, cannot save Canada's competitiveness singlehandedly. Technology's value is derived from the manner in which it is used. Thus, technology cannot be viewed in isolation; it must be viewed as a single element of a cohesive business or government strategy.

Whether we are looking at the manufacturing or service sectors, the nature of the organizational output demanded by the environment, the tools of production and the organization design used to produce that output must all be congruent. This is the only way in which a viable strategy can be achieved. When the fit between the environment, the technology and the human organization is achieved, then employee fulfillment, technological effectiveness and global competitiveness are possible. However, one outcome cannot be achieved without the other two.

It is widely recognized that, in general, the business environment is becoming increasingly complex and turbulent. Such an environment has the potential to fragment society and specifically organizational activities, as individuals and groups attempt to make sense of their immediate surroundings. Therefore, in the business setting, the fit between technology and the human organization (socio-technical design) must support an integration of activities while maintaining the flexibility to respond to the changing environment.

The purpose of this paper is first, to evaluate the present state of technology and its future trends in relation to this environmental context. Secondly, issues, for society and for the work environment, arising out of the nature of new technology, will be identified. These issues also indicate many areas which should be addressed by government. Finally, the implications of technical design will be considered in relation to the concept of organizational choice.

2.0. The 'State of the Art' Technology and Specific Trends

2.1. Artificial Intelligence

The term 'artificial intelligence' is really a misnomer. At present, we do not have electronic equipment that can be said to 'think', it merely performs the functions that it is programmed for. However, today, those functions are becoming quite extensive.

Artificial intelligence is a software umbrella that covers most of the new technologies. Applications of artificial intelligence include, but are not limited to, robotics, natural language processing, computer vision, voice recognition, computer language translation, computer-assisted learning, computer-aided design, computer-integrated manufacturing and expert systems. Expert systems are the latest, fastest growing commercial product in the artificial intelligence field. In fact, the term artificial intelligence is often used incorrectly as being synonymous with expert system.

2.2. Expert Systems

Expert systems are computer programs which can capture, in memory, specialized knowledge acquired from a human expert and then process that knowledge using similar processes as the human expert in order to solve difficult problems. Expert systems can include extensive numerical calculations; however,

their advance over traditional data processing is that they also use symbolic and often qualitative reasoning.

The expert system's architecture includes the user interface, the knowledge base and the inference engine. The user interface today makes use of written communication; however, future expert systems will make use of advances in voice communication.

The knowledge base is the expert knowledge stored in memory. It is encoded through the use of three techniques. First, production rules are "if - then" rules used to represent the consequences of given conditions or actions. Second, semantic networks are used to represent knowledge that consists of sets and subsets. Third, frames are used to store many different kinds of information about a single object.

The inference engine contains the reasoning methods for using this knowledge base. Two reasoning methods often used are forward chaining and backward chaining. Forward chaining, as the name implies, is employed when the user wishes to start with certain conditions and work through the program to the appropriate decision. Backward chaining is the reverse process where an outcome is specified and the program is used to work backwards to indicate the required conditions for that outcome (1).

Expert systems can be used for many stages of the work flow. Applications include prediction, diagnosis, design, planning, alarm analysis, monitoring, simulation, repair, instruction, interpretation and control. Because expert systems have such a broad scope of application, they have major implications for future employment levels and job design.

Expert systems offer the potential ability to speed up decision processes by absorbing some of the work load. They can, therefore, provide an organization with the time to respond to a changing external environment. This scenario

demonstrates the use of expert systems as support systems for humans. The expert system processes some of the knowledge and reasoning steps, while the human expert guides the direction of the overall problem-solving process and ensures that all pertinent knowledge has been incorporated into the system. However, the opposite scenario also exists. There are those designers, developers and users of expert systems that view them as stand alone units which will replace human experts.

2.3. <u>Computers</u>

The hardware includes mainframes, mini-computers, and personal computers which can be connected in many configurations. The software can extend from traditional data processing capabilities to more advanced artificial intelligence applications. The software is no longer only processed by a single central computer; instead, it can also be handled by decentralized units connected together in a network and processed in independent blocks or interactively between two or more users.

The expert systems of the future will require computers that are able to perform very complex problem-solving. The present sequential computers are too slow for such advanced tasks. The computers of the near future will be parallel inferential machines which have a number of processors able to concurrently process different portions of the problem. A lot of progress is being made in this area both in Japan and in North America (2).

For the more distant future, computer hardware technology is moving in two separate directions: towards an optical computer and a neural-net computer. However, the goals of both designs are greater speed and flexibility.

The optical computer offers the promise of much greater speeds (exceeding 17 trillion bit operations per second compared to billions of bit operations per second for electronic

computers) and the flexibility to reorganize the hardware through reprogramming. Changing the hardware configuration will be as easy as reprogramming software is today. This is possible because, whereas electrons in electronic computers are confined to conductors, light can be transmitted and reflected anywhere. This flexibility can more closely simulate how we believe the human brain operates (3).

The neural-net computer uses traditional transistors; however, they are connected in parallel rather than in series, as is the case in conventional computers. This is modelled on the pattern of nerves in the human brain and offers much faster operation. The developers claim that this approach produces truly intelligent computers that can think, learn and even invent, that is, computers with the flexibility for "dealing with unforeseen situations" and "synthesizing knowledge from random data with little or no human help"(4). This capability is called "pattern mapping" and is critical for such things as comprehending speech and artificial vision. This technology is still in its infancy and full neural-net computers are probably still 10 to 20 years away. However, several neural-net companies plan to commercialize plug-in boards that will simulate neural-net operation on conventional memory chips as early as this year (5).

2.4. Robots

Robots are manipulators that can perform many different tasks and are reprogrammable. Robots come in many shapes and sizes; however, they can be placed into four general mechanical classifications which broadly describe the coordinates of their work surface: articulated (with one or more rotary joints), cartesian (straight line arm movement only, although they may have a pivoting wrist joint), cylindrical (a rotating horizontal arm moving on a vertical column) and spherical (rotary and pivotal motion of a retractable arm) (6). Robots can be used for either performing work on an object or for transporting objects from one work station to the next.

The Society of Manufacturing Engineers' **Delphi forecast of trends in robotics in the U.S.A.** predicts that by 1995, 15% of new robots will use multiple arms and 29% will have some degree of mobility. There will also be an increase in velocity, repeatability and the number of degrees of freedom. The use of sensors will increase dramatically and robots will be purchased as part of computer integrated manufacturing systems rather than as stand alone units (7).

These forecasted increases in the flexibility of the robots themselves will make the production processes more flexible and thus enable manufacturers to respond faster and with more variety to customer demands.

2.5. Computer Aided Design (CAD)

Computer Aided Design is a software system which is replacing the drafting board and incorporating that function within the engineer's scope of responsibility. Engineers can use the CAD units to assist in the design of parts and processes, perform calculations, test and simulate operation and store 2-D, 3-D or solid images and other information. If the CAD unit is also connected to peripheral equipment, then microfilm and blueprints can also be produced electronically from CAD memory. Or tape, magnetic disc and optical disc can be used for permanent storage of information. CAD can be used with dedicated specialized terminals or the same hardware as other computer applications.

The major advantages arising from CAD are the potential opportunities for increased creativity from designers, flexibility and faster turnaround time (8). Also, if CAD is used as part of a CAD/Computer Aided Manufacturing (CAM) system, then numerically controlled manufacturing equipment can be programmed from the CAD data.

To date, the use of CAD has been limited because of the high equipment costs and the frequent incompatibility between CAD and industrial machine tools, mainframe computers and other electronic equipment. However, costs are falling rapidly and standards for equipment communication are being developed. This means that increases in the use of CAD and CAD/CAM systems are forecasted, particularly in small business(9).

2.6. Flexible Manufacturing Systems (FMS)

Flexible Manufacturing Systems are networks of numerically controlled machine tools controlled by a computer. However, there is no firm definition and the terminology is often used to include robotics and automated materials handling as well.

The key characteristics of FMS is its flexibility. Whatever combination of manufacturing equipment the term covers, the individual pieces of equipment must be reprogrammable so that their operation can be changed very easily. This flexibility allows the products to be customized and theoretically makes a batch size of one economically viable.

Flexible Manufacturing Systems change output from mass production to batch production with little loss of economies of scale. When this equipment flexibility is coupled with shortened throughput times, created through the use of parallel work stations for example, then the production process is converted from mass production to continuous flow production.

2.7. Computer Aided Manufacturing (CAM)

Computer Aided Manufacturing is a manufacturing process that uses computer controlled equipment to perform some or all of the manufacturing operations. The computer controlled equipment can range from single numerically controlled (NC) machines to flexible manufacturing systems often used together with process control devices, automated assembly systems and

computer-aided inspection. The computer controlled equipment can be controlled by decentralized software, used together with CAD or as part of a Computer Integrated Manufacturing network. The CAM software takes the design data from CAD and converts the information to NC code.

Like CAD systems, the use of CAM is expected to rise rapidly in the near future.

2.8. Computer Integrated Manufacturing (CIM)

Computer Integrated Manufacturing uses centralized computing technology to integrate a number of technologies to produce coordinated operation as a whole. The plant that uses CIM is often referred to as the automated "Factory of the Future". The technologies most often integrated by CIM are CAD, Group Technology and Manufacturing Planning and Control Systems under the domain of the engineering department together with Robotics, CAM and Automated Materials Handling under the domain of the production department. Please see exhibit 1. However, CIM can also be used to include accounting, inventory control and other business planning functions in the integrated operation.

Today, it is extremely rare to see CIM in operation. However, the introduction of computer standards is expected to open up this field very quickly.

2.9. Telecommunications

A work place telecommunications network is used to link many computers together as well as link the peripheral devices and equipment to the computer system. When this is connected to the external telecommunications network, then whole organizations can be electronically joined.

The migration from analog to digitally encoded signals has enabled the integration of voice, data, text and image media

to take place. The introduction of fiber optic cables has allowed the digital signals from all media to use a single transmission line concurrently without interference(10). At present, the potential use of integrated services (such as video teleconferencing or integrated voice and data) is only available in large centers. However, the future increased use of fiber optics means that these services will become available to all communities.

2.10. Office Automation (OA)

Office Automation is the term used to describe a diversified selection of electronic office equipment and the process of connecting that equipment into a network. This technology would not have been possible without the advances in digital data transmission made by the telecommunications industry.

However, the concept of office automation goes further than just having the ability to connect information processing equipment from all media into one network. For the whole is greater than the sum of the parts. Although today few devices exist that truly integrate voice and data into simultaneous communications, in the near future, simultaneous interactive communication and information processing will commonly take place between pieces of equipment and across media. This will have major implications for organizations. Then, much of the internal office communication will take place electronically and the organization will be connected electronically with the outside world.

Today, few offices are fully automated and office automation is being purchased in a piecemeal manner. However, the rate of automation is expected to increase rapidly as is the scope of equipment which is embraced by office automation.

3.0. Overall Trends in New Technology

There are three main trends that new technology is following. They are:

(1) increasing flexibility;
(2) increasing integration;
(3) increasing scope of automated decision processes.

These trends apply to technologies used in both manufacturing and office work environments.

3.1. Increasing Flexibility

The increasing flexibility of the new technology enables an organization employing it to become more flexible in the way it operates. This in turn offers the organization the potential to become more proactive with its increasingly turbulent environment. Therefore, this trend is both appropriate and essential to ensure the future competitiveness of Canadian business.

This trend can be broken down into two subtrends: the flexibility to change and the flexibility to grow.

3.1.1. The Flexibility to Change

The new technologies provide the flexibility to change either the output of an organization or the work processes used to produce the output or both. Old technologies which had specific tasks reflected redundancy of parts, that is, a single piece of equipment had to be replaced with a similar item. However, the flexibility of new technologies means that one item of equipment can perform many tasks. Thus new technologies are reflecting redundancy of function.

3.1.1.1. <u>The Manufacturing Plant</u>

In a manufacturing plant that employs new technologies, software changes can be used to rapidly adjust output production specifications. Prior to automation, the machine tools would have required retooling in order to make such a change. This would have been time consuming and have resulted in lost production. As a result, this procedure was undertaken very infrequently. This is part of the rationale behind mass production. Therefore, the new technologies offer a manufacturer the flexibility to move away from standardization and mass production with little loss of economies of scale.

The new technology also offers the potential to change work processes. The increasing use of general purpose robots instead of specific task robots gives the plant operators the flexibility to change the work process. Although the flow of the physical product must still essentially remain sequential, the robot can be reprogrammed to use different tools and thus the nature of the work performed at each station can be changed.

In the past, human work processes were such that one person could not perform his/her task until the person preceding his/her had completed his/hers. This sequential arrangement reflected the work flow of the product. However, now, the new human task of 'monitoring' the technology (as opposed to 'doing' the task) can be performed independently and pooled to create the total production process. Thus the human task has become removed from the physical product by the technology and people are less dependent upon each other for the performance of their task. Therefore, the human work flow becomes more a pooled coupling than a sequential coupling.

3.1.1.2. The Office

In an office that employs new technologies, software changes can be used to rapidly change the form that the output takes. For example, calculations can be reprogrammed to include new factors or the format of text presentation can be adjusted through reprogramming.

Also, the very act of introducing office automation can change the work process in an office. In a non-automated office, the paper or information must flow sequentially from one person to another so that each can extract, add or manipulate information. However, if an office has a network of electronic equipment (personal computers, mainframes, minicomputers, etc.), then each person can access a central base of information as and when needed. Although one person cannot access information until it is entered into the system by another (or electronically) each is less dependent upon the other for work flow. Therefore, as in the manufacturing plant, the human work process can become more a pooled coupling than a sequential coupling.

3.1.2. The Flexibility to Grow

The modular design of both new manufacturing and new office equipment allows the system or network to be expanded or converted from old to new technologies in small increments as and when required.

3.1.2.1. The Office

Because the product of an office is often intangible information rather than a solid object, this flexibility is greater in an office. One individual work station can be connected to a network at a time. The ability of new

technology to change the coupling of work from sequential to pooled interaction allows this flexibility to be recognized.

3.1.2.2. The Manufacturing Plant

In contrast, in a manufacturing plant, the flow of the physical product usually remains sequential. Therefore, if one single piece of equipment is replaced by a robot, it is necessary to ensure that it is compatible with the old technology used on either side. Also, a single robot in a production line will be constrained by the speed of the human operators on either side and probably would not achieve its full potential. However, although the flexibility to grow in a piecemeal fashion is not as great as in an office, it is possible to use this approach to achieve some limited increase in operational flexibility at individual work stations.

This limited flexibility can be enhanced if the new technology is used as a stimulus to convert a single sequential production line into several parallel work station groupings. If this approach is used, then one grouping at a time can be converted to use new technology and new groupings can be added as required to meet the demand.

3.2. Increasing Integration

The trend towards increasing integration can be broken down into two linked subtrends, the increasing integration of multi-vendor equipment and of information media. This integration of devices and services is being achieved through the use of international standards such as Open Systems Interconnection (OSI) and Integrated Services Digital Network (ISDN).

OSI is a world standard which will allow equipment from all vendors to "talk" to each other. This capability gives the user more flexibility to develop generic networks of devices

that better suit the organization's needs rather than requiring the user to operate isolated devices or to choose equipment offered by a single vendor. Also, it means that eventually all organizations will be electronically compatible.

When this capability is combined with ISDN, which is a world standard that will allow connection of voice and non-voice service devices to a digital network using a device similar to the telephone jack, then organizations will be able to communicate, via the public communications network, anywhere around the world-- or even extraterrestrially!

This increasing integration, for good or bad, is eliminating the internal and external boundaries of organizations. Integrating voice, image, text and data electronically and connecting all equipment into a single system means that departments can potentially access and even change each other's information without verbal or paper communication. The reduction of departmental boundaries can be used beneficially to speed up the internal operations of an organization and to make the best use of the increased flexibility offered by the new technology, thereby improving information flow and decision making. However, there is the potential for this reduction of departmental boundaries to be used maliciously. With access to another department's information, a department intent upon sabotage could have a free rein. There are administrative programs available to control this access to information and the ability to manipulate it. However, it is imperative for an organization to make a conscious decision about who has access to what information and how much freedom to change information by any one person or group is tolerated. To allow total access to information by default is courting disaster.

I suggest that whether the reduction of internal boundaries is used beneficially or not depends to some extent upon the organization's culture. This in turn is expressed in the

structure and processes of the organization. Therefore, when making a choice about access to information, an organization must combine this choice with the wider choice of organizational structure and processes.

3.2.1. The Office And The Manufacturing Plant

A good example of how the integration of devices and the resulting reduction of internal boundaries can be used to provide increased speed and flexibility of operations within the manufacturing plant is provided by the plant that uses CIM (Please see exhibit 1). This diagram shows how the boundary between engineering and production is eliminated by CIM. The design of a product on the CAD system can be used to automatically program the FMS. The need for extensive human communications between production and engineering is eliminated.

This integration is also changing the office environment. With the increasing use of optical disks, images of whole documents can be converted to digital code and stored, rather than the receiver inputting only selected data from these documents. These optical storage devices can be integrated into a digital network, thus allowing one department to access original documents electronically from another department to obtain information to incorporate into their own documents. Also, the users only need work on a single piece of equipment to integrate several media. The ability to access original documents can cut down input errors and the integration of several media and devices into one network eliminates the internal boundaries between the receiving department and the using department.

In addition, the introduction of national and international standards makes it possible for either office or manufacturing organizations to become electronically connected to supplier and customer networks. Therefore, supplies can be ordered,

customer orders processed or bills paid without human intervention.

3.3. The Increasing Scope of Automated Decision Processes

Earlier software was used to program simple, repetitive, quantitative tasks. For example, robots were programmed to perform the same movement all the time or computers were programmed to manipulate data in a set manner. These activities covered the decision making domain of blue collar or low level office workers. However, now that artificial intelligence is available to process qualitative as well as quantitative information and real-time applications are possible, automation is entering management's domain. The scope of automated decision processes has broadened to capture responsibilities positioned higher on the corporate ladder.

The ability to automate more and more decisions will speed up the decision making process and allow management more time to deal with the organization's turbulent environment. Management will no longer spend its time in detailed problem solving; this will be performed electronically. Instead, they must make decisions using a process known as "puzzling." This is the only appropriate way of dealing with a turbulent environment. They will use the problem solving performed by the computer as an input to this puzzling process to test many options and provide the potential for better quality decisions. Therefore, the relationship between the human and technology becomes more critical in a turbulent environment and will become crucial to maintaining global competitiveness. However, this loss of scope of routine decision making is threatening to management, just as it was to lower level workers in the past. Therefore, its implications and possibilities will have to be thoroughly understood if management is to accept the new technology and use it to its full potential.

4.0. Issues

New technology is generating many issues that must be addressed by our business, labour and government leaders. Not to address these issues, I believe, will lead to mass social stress. New technology is changing our lives at an increasing rate which cannot be halted. Change creates fear which leads to stress. This can generate a 'fight or flight' response. We cannot flee new technology as our society is inextricably linked with global activities. Therefore, to ignore or remain reactive to new technology will probably lead to an escalation of adversarial relationships. This in turn will just increase social stress, make us less able to cope with a changing environment and thus produce a vicious cycle.

However, if business, labour, government and other interest group leaders can develop some common ground and combine their efforts to jointly take a proactive stance with respect to new technology, then our society can make the best use of new technology to enhance our lives. The goal of such a proactive stance is to identify issues early so that they be dealt with in an effective and less stressful manner.

Therefore, to identify present and future issues arising from new technology is critical. Some of these issues are discussed here. The issues have been separated into those pertaining to the work environment (micro level) and those pertaining to society at large (macro level) for discussion purposes. However, they cannot be completely separated because the issues from one level overlap or generate new issues for the other level. Also, it should be noted how diverse these issues are. This diversity demonstrates just how much of our lives new technology is touching.

4.1. Social Issues

4.1.1. Polarization of the Workforce

The advent of expert systems has meant that organizations are no longer totally dependent upon human experts to make complex decisions. Once the human expertise is captured in the computer memory, whether or not the human expert remains with the organization becomes less critical. Also, expert systems are designed to be user friendly so that a non-expert can run the program and theoretically make expert decisions.

Therefore, if society permits decisions to be made that lead to expert systems eventually being designed as stand alone units that require little expert knowledge to operate, then the workforce could become polarized. User organizations of new technology will require generalists that can evaluate the direction of the whole organization while expert decisions will be made by the electronic equipment. In contrast, R & D organizations and manufacturers of new technology will require specialists that can design, manufacture and program the expert systems for the user organizations.

If this polarization takes place, then user organizations will no longer have the necessary expertise to reprogram expert systems to include changing environmental considerations and outside expertise will become costly. This will create the possibility that the necessary changes will not be made and our products and services will cease to remain relevant to society's needs. Also, society must ask the question: What do we allow to become totally electronically controlled? For example, should nuclear power plants be totally controlled by computers? or defense decisions?

These capabilities will be available in the near future . The decision of whether to use expert systems as stand-alone units or human support systems must be made now, while the concepts

are in their infancy and before we become irrevocably committed through default.

4.1.2. Education and Health Policies

As most tasks requiring low level education and even many requiring higher education are taken over by the new technology, many people will need retraining. Much of this will consist of on-the-job training; however, the demand placed on our educational facilities will also increase. This will translate not only into higher costs but also into a need to reevaluate the distribution of funds. It will become increasingly important, as technology touches more and more of our lives, for all of us to have some technical knowledge. Therefore, greater emphasis and funding will be required by technical programs.

Also, if health and safety issues arising directly and indirectly from technology (addressed later in section 4.2.1.) are not considered now, then we can expect to see an escalation of health costs as a result of the new technologies. I suggest that it will be a lot cheaper in the long run, as well as more beneficial to society, to implement preventative health care now rather than remedial health care later.

4.1.3. Remote Manufacturing

If we reach the state where manufacturing processes are fully automated and can be controlled completely by computer, then we will probably start to see remote manufacturing. A manufacturing plant in one location will be operated via telecommunication links from another location. If this becomes the case, then manufacturing facilities will be located where land is cheap, such as rural areas. Also, if manufacturing plants are totally unmanned with no human presence to correct for unforeseen circumstances, then the

possibility of major industrial accidents is higher. This would cause greater environmental concerns.

Remote manufacturing also offers the potential for developed nations to exploit the environment of third world countries. Even if we were to be socially responsible about our own environments, would we extend that concern to third world countries? Eventually, if unmanned remote manufacturing becomes a reality, then there is also the possibility that we will begin to manufacture in space via satellite. As space knows no national boundaries, this would open up international debate over domains in space and the global environmental impacts of industrial accidents in space.

4.1.4. Electronic Cartels

As has been already mentioned, the new technology has the potential to reduce the external boundaries of organizations. This has beneficial implications for an organization in communicating with customers, suppliers, governments, etc. Communications will be faster and more timely. However, this possibility of electronic external communications could also be extended to include competitors.

In an attempt to become more proactive in relation to the environment, whole industries could be connected electronically. It would be possible for "competitors" to communicate their intentions to each other faster and less openly. At its extreme, this practice could lead to the formation of electronic cartels. Such activity would have implications for antitrust laws.

4.1.5. The Handicapped

In the not too distant future, two way verbal communication with computers will become a reality. This has the potential to open up additional employment opportunities for the handicapped in careers that are at present unattainable.

The government, as well as interest groups, need to actively monitor these technical developments so that they can encourage both the handicapped and business to take advantage of this outcome.

4.1.6. <u>Women</u>

The Economic Council of Canada's (ECC) **Survey of Automation in Canada** (11) shows that 16 percent of women were working with new technology in 1985 compared with 12 percent of men. They attribute this fact to two reasons. First, new technology is being accepted more readily into the service sector which traditionally employs more women. Second, almost two thirds of new technology implementation between 1980 and 1985 was in the office, where female employment is high.

Therefore, new technology is an important issue for the women's movement. The majority of women's jobs that are affected by new technology are clerical. The clerical jobs are not disappearing (in fact, the ECC survey shows that they are increasing); however, there is the potential for them to become deskilled, mindless jobs. It becomes increasingly important, as technology advances, to encourage young women to pursue professional careers. It is also critical that more women be encouraged to enter technical careers so that women's concerns can be incorporated into technology in the design stage.

4.1.7. <u>Employment</u>

There is much controversy over whether new technology is eliminating jobs by automating them or creating jobs through offering the potential for increased sales and competition. There are examples of both scenarios.

I suggest that the latter scenario can only take place if there is a fit between the environment, the organization

design and the technology. If the new technology is implemented in a bureaucracy, then the organization is too rigid in its operation to achieve the flexibility offered by the technology and demanded by the environment. Thus jobs will be lost. On the other hand, if the new technology is implemented in an organization that has a flexible design which can make the best use of the flexibility of the technology, then the organization can respond to its environment. The organization will be more competitive and the opportunity for increased sales is available.

Hence, government can have a potentially favourable impact on employment levels by encouraging and assisting in the implementation of flexible organization designs.

As well as affecting employment levels, new technology also has the potential to alter the balance of the full time - part time labour force. The ability to communicate electronically without need for physical proximity is creating an increase in the service sector in using home as the workplace. This form of work is also usually part time work. While this arrangement is welcomed by some, it is being forced upon others.

4.1.8. Awareness of The Issues

Important in its own right is the issue of how aware the different stakeholders are of the many implications of new technology.

Business and government appear to address the need for new technology mainly in terms of productivity advances. Little recognition is given to the design of the human organization or the impact of technology upon the worker.

Unions, in large part, appear to be attempting to resist the spread of new technology. By concentrating on the negative consequences of new technology, they are missing some of the

positive impacts upon the work environment of their members that can result from combining technical and human organization design. The union philosophy of standardization and formalization of an adversarial relationship with business enhances and builds upon the bureaucratic form of organization. Unions fail to recognize that the organization that adheres to more flexible human organization and combines this with new technology offers the union an opportunity both for greater involvement in, and for making a greater direct impact upon, the work setting.

The engineering schools that produce the engineers who will design our future technologies for the most part continue to concentrate on the technology to the exclusion of the social impacts of that technology. There is some indication that this practice is slowly changing with the introduction of compulsory courses in ethics into engineering curriculae. The founding of the Center for Technology and Society at the University of Toronto is another positive step. However, greater emphasis is still needed in this area if society rather than the technology is to direct how that technology is to be used.

The women's movement has a good awareness of the impact of technology on the worker. This is a direct result of its membership makeup. However, it is also the group with the least ability to change how technology is used because women have the least expertise in the technological arena.

4.2. Issues for the Work Environment

4.2.1. Health and Safety

The impact of new technology on health and safety is an issue which is still not fully understood. As we are still learning about the effects of new technology on health and safety, government needs to be a major player in the identification and resolution of this issue. Government needs to be

involved, not only in the development of new legislation, but also in the dissemination of information. The civil service needs to act as a coordinator of health and safety information between organizations, so that one organization can learn from another's experiences. Given the high rate of change in technology, we have neither the freedom to play with human health nor the time to allow all organizations to learn the same lessons through practice.

The health issue can be separated into physical and mental concerns. Physical health side effects of new technology include such things as the possible effect of radiation from video display terminals (VDTs), the possibility of increased occurrences of heart disease from the increased passivity of work and increasing incidences of tenosynovitis.

There is still much controversy over how much exposure to VDTs is acceptable, especially during pregnancy. This issue requires much more investigation into the establishment of "safe" levels of radiation and into whether technological advances are possible to remove or screen the radiation.

New technologies have the potential to eliminate most physical activity from a job and substitute mental activity. In the office, the physical activity of walking from one location to another to obtain information or to communicate can be replaced by electronic communication. Although electronic communication is faster, it also means that the worker can spend all day sitting at his/her desk. In the manufacturing plant, the task of monitoring a robot's activity requires much less physical movement than actually doing the task oneself. Therefore, the passive nature of work created by the new technology could result in lower fitness levels in the work force. This in turn could result in increased incidences of heart disease, obesity, etc. An interesting research program would be to study whether workers faced with this change compensate through increased fitness programs outside of the workplace. It is conceivable that the implementation of new

technology would require an increase in in-house fitness programs to keep workers healthy enough to remain productive.

Tenosynovitis is the repetitive strain injury arising from the use of electronic keyboards. It did not appear with the typewriter and is therefore a health problem directly linked to new technology. Fred Emery (12) has offered two hypotheses for the cause of tenosynovitis. The first is that a strain threshold has been passed. This is a result of the faster speed of electronic keyboards which has allowed the establishment of higher standards for keystrokes/hour. This hypothesis suggests that job design could eliminate the need for continuous keypunching and thus eliminate the symptoms. The second hypothesis is that there is a design fault in the electronic keyboards. Our sense of touch may require the stiffness present in the mechanical typewriter but eliminated in the new electronic keyboards, in order to function effectively. As a result of the lack of pressure on the finger and knuckle joints, the cartilage of these joints may become malnourished. It is possible that our bodies can adapt; however, this hypothesis calls for research into both the design of electronic keyboards and our sense of touch.

The side effects of new technology on mental health manifest themselves in the form of stress. Stress can be felt in two ways: through interaction with the technology itself, and through the impact that technology has upon organizational structure and processes.

First, new technology offers great leaps in performance. The speed and accuracy made possible by new technology is exciting to some people. However, if the potential performance levels of new technology are used to set standard levels of performance for all human operators, then the technology can be seen as a threat to dignity and self esteem. This is particulary true if the new technology is used to monitor both whether these performance levels are met and for general surveillance of activities. This form of electronic

surveillance requires some measurable indicator of performance such as keystrokes per hour or length of time per phone call. Thus the stress resulting from the "invisible boss" is more common at the lower operational level of an organization. Also, the loss of control over a task that has been automated can cause a feeling of powerlessness. As was mentioned above, this powerlessness resulting from automation has been felt by lower level workers for many years and is just recently being experienced by managers.

Secondly, if new technology is allowed to further bureaucratize the workplace by task standardization (keystrokes/hour, etc.), then the organizational structure and processes will become so rigid as to cause additional stress. Rules and procedures will be built around the technology and the human element of work will be lost. In contrast, innovative, more flexible and democratic organization design can use technology to alleviate some of the monotonous work and thus eliminate stress from that source. Therefore, new technology can have both a direct and an indirect impact upon human stress levels.

4.2.2. Job Design

As automation has become more and more sophisticated, job design has changed drastically. Initially humans performed the tasks. Then, the human's job was to monitor the equipment's performance of the task and to interpret the results. Now that electronic equipment can perform the monitoring tasks associated with manufacturing production or information status, the human task has progressed to the control of the unexpected. Even though our environment is becoming increasingly turbulent, the unexpected still occurs intermittently. This allows more tasks to be handled per person.

Whether this increase in job content becomes job enrichment or merely job enlargement depends upon the organization's design.

Job enlargement, increasing the number of similar tasks that a person performs, provides little employee satisfaction or motivation. However, if technology is used to allow job enrichment, adding new tasks to the core job, then the person can see his/her impact on a larger portion of the total work and thus obtain satisfaction and a sense of accomplishment which helps maintain high levels of motivation.

Technology can support either extreme or any combination of these two options. The route taken depends upon how the organization is designed to perform its activities. However, whichever path is chosen, clearly some degree of job redesign is required.

4.2.3. Training

The need for job redesign translates into a need for increased training. If the job redesign takes the form of job enlargement, then the training must cover how to interact with the technology. If the job redesign takes the form of job enrichment, then the training must also include the skills for increased responsibility. Therefore, the direction in which our training facilities move depends upon the direction of organizational change.

The Economic Council of Canada's **Survey of Automation in Canada** (13) shows that the retraining being provided by organizations implementing new technology today is often of a short-term nature. They found that one-half of on-the-job training and over 80 per cent of classroom training lasted four weeks or less. This could possibly be a major stumbling block to the continued competitiveness of Canadian business. This finding suggests that retraining is viewed as a temporary, reactive adjustment to the technology rather than an ongoing, proactive relationship that allows the technology to be used to its full capability.

4.2.4. High Tech. - High Touch

As was mentioned earlier, new technology is breaking down the internal and external boundaries of organizations so that information can flow between departments and organizations more easily. Communication can be made electronically and little human contact is required in order to perform the tasks. However, this capability is socially isolating people within the workplace. Therefore, even though new technology breaks down an organization's boundaries for information flow, it also has the effect of erecting boundaries to social contact between individuals.

Humans are basically social and need some interaction with fellow beings. Therefore, in order to develop happy, satisfied, committed workers organizations need to allow for some social contact. When implementing new technology, the organization must be redesigned to stimulate this socialization. Hence the notion of 'high tech - high touch'.

4.2.5. Organizational Choice

The four issues raised in this section call for some degree of organizational restructuring when new technology is implemented. These issues can be combined with one final issue: the need for organizations to make a conscious, deliberate decision about how technology is going to be used within the organization. This decision involves: what technology is going to be used? who is going to use it? how will they be organized to use it?

The need for this issue to be considered is demonstrated by the fact that in the past when new technology has been implemented in organizations, many conflicting results have been observed(14). For example, in some organizations the employment level has dropped while in others it has increased. Therefore, the outcomes of implementing new technology alone cannot be completely predicted ahead of time. This suggests

that organizational setting plays a large part in determining the success or failure of new technology application.

The actual organization design details chosen can successfully take many forms; however, a fundamental choice is whether to select, as a base, what is termed the old paradigm or the new paradigm. The old paradigm is the traditional, bureaucratic system whose basic design principle is redundancy of parts. Redundancy of parts refers to the high specialization of tasks, such that individuals are viewed as replaceable parts of a machine. In contrast, the new paradigm has as its basic organization design principle redundancy of function. This recognizes that people can successfully handle several tasks or develop multiple skills, and each person is trained accordingly. The organizational building block that reflects completely the pure new paradigm philosophy is the semi-autonomous work group. This new paradigm is expressed in the 'Quality of Working Life' (QWL) concept. The new paradigm is a mode of operation that provides the flexibility needed for an organization to be proactive with its turbulent environment. In fact the new technology is promoting this proactivity in relation to a turbulent environment. As was mentioned above, new technology reflects redundancy of function, which is also the underlying principle of the new paradigm. The characteristics of new technology are consonant with the notions of flexibility and choice so central to 'Quality of Working Life' thinking, and thus can push the organization in this direction.

If new technology is implemented within the context of the old paradigm, then technological effectiveness is limited by the rigidity of the bureaucracy. However, if new technology is implemented within the context of the new paradigm, then the full potential of the existing technology can be realized and technological effectiveness is limited only by the technology itself. Between these two extremes there are organization designs that partially embrace both paradigms and these organizations can achieve varying degrees of technological

effectiveness. This suggests that there are levels of technological sophistication appropriate to different organization designs and environmental demands.

The Economic Council of Canada's report, **Working with Technology**(15), indicates that today the number of managers as a percentage of total employment within an organization that has implemented new technology is greater than in a non-innovator organization. This suggests that more levels are being added to the existing hierarchy to deal with the new technology. This is typical of the old paradigm or bureaucratic structure. However, this expansion of the hierarchy adds rigidity not the flexibility crucial for technological effectiveness. Therefore, the potential of Canadian organizations to optimize their technological effectiveness must be questioned. Management and labour need to be educated about the possibilities offered by organizational redesign. This is a key area where government can have an impact upon the future competitiveness of Canadian industry.

These work environment issues are addressed in the next section where hypotheses of two opposing scenarios of working with technology, based on the old/new paradigm conflict, are offered for consideration.

5.0. Implications for Organization Design

Technology is never neutral in its organizational effect. For, as mentioned, technology and organization design have a combined impact upon the work environment.

When an organization purchases new technology, the nature of the workplace will bias the decision regarding the form that the technology will take. In response, the technology, because it has a heavy influence on the what, when, where, why and how of work, has the power to polarize the organization

even further towards redundancy of parts (old paradigm) or towards redundancy of function (new paradigm). Section 5.1 discusses how this polarizing effect takes place.

5.1. The Combined Impact of Technology And Organizational Choice On Work

The nature of the new technology selected and the manner in which it is used can enhance the detrimental structures and processes of an old paradigm environment or the beneficial structures and processes of a new paradigm environment. Figure 1 lists some areas of technological impact, and I hypothesize that these impacts when implemented in opposing organization settings are also diametrically opposed. Because technology has this characteristic of polarizing organizations, it is important that the organizational choice be made prior to or in conjunction with the technical choice.

Figure 1

The Combined Impact of Technology and Organization Choice (16)(17)

Areas of Impact	New Technology Implemented In An Old Paradigm Setting	New Technology Implemented In A New Paradigm Setting
Employment Level	Decrease	Potential Increase
Skills	Obsolete Skills/ Deskilling	New or Enhanced Careers
Socialization	Less Social Contact	More Social Contact
Performance Measurement	Negative Feedback	Positive Feedback
Flexibility of Schedules	Rigid Hours	Potential for Flexible Hours
Flexibility of Work Place	Fixed	Potentially Flexible
Scope of Work	Job Enlargement	Job Enrichment
Location of Control	Centralization	Decentralization
Power	Concentrated with Technically Literate	Dispersed to Users
Technical Ideology	Technology Is In Control	Technology Is A Tool

5.1.1. New Technology and The Old Paradigm

The old paradigm setting is characterized by a "one person-one task" division of labour. Therefore, the technology that is purchased is usually selected to fit with this traditional manner of work assignment or to make it even narrower.

Organizationally this environment does not permit flexibility and creativity to surface. No single person has a sufficiently broad job to see enough of the total operation to enable him/her to develop new products (services) or new ways to perform work. The technology is not capable of stimulating innovation if the human vision is not present to guide and direct it. Therefore, such an organization is less likely to remain competitive in the customer-oriented, creativity-demanding marketplace that we are increasingly experiencing. This will result in a shrinkage of business activity and a loss of jobs.

Also, when tasks are so narrowly defined, the technology is more likely to be selected to duplicate exactly that rigid definition of work. This will lead to either the complete displacement of tasks (skill obsolescence) or the reduction of tasks to a mundane monitoring of the equipment.

In an old paradigm environment, traditionally tasks are coordinated through the use of rules and procedures. These can be programmed very easily into the computer equipment being used. Thus, now that technology is becoming so integrated that information can be transmitted and communication can take place between individuals and departments electronically, there remains little need for human contact. In this situation, then, there is a tendency for people to become isolated. In addition, due to the ease of implementation, there is the tendency to create more rules or procedures.

Another impact of technology structured to fit formalized tasks is that it becomes very easy to monitor performance within these discrete units of work. Measures of use can be gathered by the equipment and compared against preprogrammed standard levels of performance. This is a very negative, destructive form of performance evaluation where often the only feedback that the user receives is punishment for failure to meet the standards. Even when the equipment is also programmed to recognize good performance, the feedback is often provided via the technology. Thus, praise or warnings also become very impersonal.

Even though new technology is integrated to the extent that it often offers the potential to eliminate the sequential nature of work flow, an old paradigm environment does not allow this potential to be used to its fullest. The new technology is forced to fit the traditional division of labour and the work flow coordinating procedures must, therefore, still remain. Thus, people must still be in the right place at the right time to perform the task when the formalized procedures say it is required. Potential flexibility in work schedules or work place has been largely constrained by the nature of the organization.

New technology can perform tasks faster than the human. Therefore, productivity increases are potentially possible. When the technology is implemented in narrowly defined pockets, this productivity increase is usually channelled towards producing more of the same task within a certain time period. For the human user, this is job enlargement and, depending on the standard rate established, can produce considerable stress. This in turn can create alienation from work and the workplace, and result in lower, rather than increased, productivity.

The decisions that are made at the lower levels of the old paradigm organization are of the kind that are very formalized. Since technology is still largely designed based

upon rigid logic, it is very easy to program formalized decisions into the technology. Therefore, the need for human decision making at the lower levels of the organization is eliminated and allows management to extend its control of the operations through the technology. Thus technology implemented in the old paradigm setting often vertically centralizes decision making to a higher level within the organization.

Because it affects people and the workplace so widely, technology is a very influential source of power. When there is a very narrow task assignment, the users are not very powerful. They often have no opportunity to experience the full potential of the new technology or have any say in the way in which the technology is used. Instead, the technology is purchased and operating procedures are established and controlled by management information systems (MIS) departments. Therefore, technology has the potential to shift power from the users to the technically literate i.e. from line to staff roles.

The way in which new technology impacts upon humans, work and their organization is largely determined by the organization's ideology. The old paradigm promotes a strategy of 'divide and control'. This division and control of the organization can be achieved through or enhanced by the implementation of new technology. This strategy leads to the view within the organization that the technology is in control.

5.1.2. New Technology and The New Paradigm

In contrast to the old paradigm, the new paradigm setting is characterized by the concept of multi-skilling or redundancy of functions. In this environment, technology is usually selected so that it can broaden the variety of tasks available to the user.

Since new technology provides an organization with the flexibility continually to redesign, customize and develop new products or services economically, it requires a work force that is creative and innovative to make effective use of that technology. The multi-skilled work force working in a new paradigm atmosphere has the necessary creativity. Then, in a turbulent environment that demands that an organization be responsive to its customers, an organization which matches the flexibility of its technology to the flexibility of its work force to create a flexible, competitive output, has the potential to increase its business activity and consequently expand its employee base as well as increase profitability.

Also, when tasks are broadly defined and multi-skilling is the norm, it is hard to select equipment that can completely replace humans on a one for one basis, although specific skills may still be displaced. However, the benefits of combining multi-skilling with new technology are not limited solely to job retention. For a new paradigm setting creates a learning atmosphere and therefore the organization is more likely to train the workforce to use the new technology to its fullest potential, allowing new skills and careers focussed on boundary spanning roles to be developed to replace those production tasks lost to the technology.

As was discussed earlier, the increasing integration of new technology can lead to isolation. This has led to the recognition of the need for a "high tech - high touch" approach - the increasing necessity to design socialization processes into an organization as the amount of time people work with equipment increases. In a new paradigm work environment social interaction occurs naturally as the semi-autonomous groups coordinate their work. Therefore, the new paradigm approach is a natural way to retain human contact as the work place becomes automated.

When technology is matched to multi-skilling capabilities and used to support human creativity, it does not have the task

boundaries necessary for punitive monitoring of activity. Therefore, performance measurement is less likely to be performed by the technology and is more likely to be based upon broad objectives and minimal specification of tasks. This is a much more positive and constructive measure of performance than that used in an old paradigm environment.

When a group is responsible for a complete operation from start to finish, and an individual can perform a broad part of any operation, it reduces the dependency of one person on another or the dependency of the group on any one person. When new technology is used in this setting, the integrating nature of the technology can further reduce dependencies by often converting sequential work flow to a more pooled work flow. Therefore, this arrangement allows more flexibility in scheduling work. Also, with the ability to communicate electronically with the people physically within the organization from outside the organization, this flexibility can sometimes be extended to include the place of work.

New technology, particularly expert systems, enables non-expert workers to access expert knowledge stored within the equipment. When this capability is used in an environment where multi-skilling is the norm, the employee is able to make more knowledgeable decisions of a higher quality about a larger portion of the total operation. Therefore, the productivity increases promised by the speed of the new technology are more likely to be used to provide job enrichment rather than job enlargement. Also, this technological impetus towards providing expertise to lower levels of the organization decentralizes decision making and control of the operation to the users of the technology.

Thus, in a new paradigm setting, the users of the technology are usually more technically literate and knowledgeable than those in an old paradigm setting. Also, because the users have more control over their own work, they are more likely to be involved in specifying what technology they need, how they

will use it and when they will use it to best perform their tasks. Therefore, in this scenario, the technology has helped to decentralize power vertically from the strategic apex of an organization down to those who use the technology. Also, with this approach, the power to control the operations of an organization remains within "line" responsibility.

As was the case with the old paradigm setting, the way in which new technology will impact upon humans, work and their organization is also largely determined by the new paradigm design. The new paradigm promotes a strategy of democratization of the workplace. The technology, which when used to its full potential reflects redundancy of functions, fully supports this ideology. In contrast to the old paradigm view where the technology is in control, the new paradigm view is one where technology is a tool to provide human support where the human and the technology jointly provide competitive advantage.

6.0. <u>The Future For QWL</u>

Traditional QWL takes a socio-technical approach to organization design which jointly optimizes the social and technical systems. The basic building unit is the semi-autonomous work group arranged within the natural boundaries provided by the sequential flow of work. However, as previously mentioned, new technology can change the human task from doing to monitoring to handling the unexpected. This distances the worker from the product flow and changes the nature of the human work flow from sequential to pooled coupling. This eliminates technology as the source of a natural boundary for the creation of work groups. Therefore, technology may have progressed so far that for many situations it has made socio-technical analysis redundant (18).

Since the new paradigm social design of learning, sharing information and power redistribution is important for both future organization competitiveness and the creation of industrial democracy in the workplace, QWL must itself remain proactive in relation to the environment. It must evolve to reflect these changes made by new technologies as well as to help shape the direction of technological advancement.

Therefore, new boundaries must be defined for the creation of work groups. Some possibilities include political boundaries, and boundaries created by supplier, client or issue. The boundaries will likely be different for different organizations with different needs. Also, since these new boundaries change more frequently than the technical system did in the past, group formation will become a much more dynamic process. The organization structural arrangement is likely to be constantly in motion.

In addition, these new possibilities for work group boundaries mean that work groups will need to include functions other than just production. For example, client-based work groups will likely need to include marketing or customer support representation. Thus, future QWL arrangements will help bind the whole organization towards becoming a flexible, adaptive entity that can respond to its competitive environment while concurrently addressing the needs of its workers.

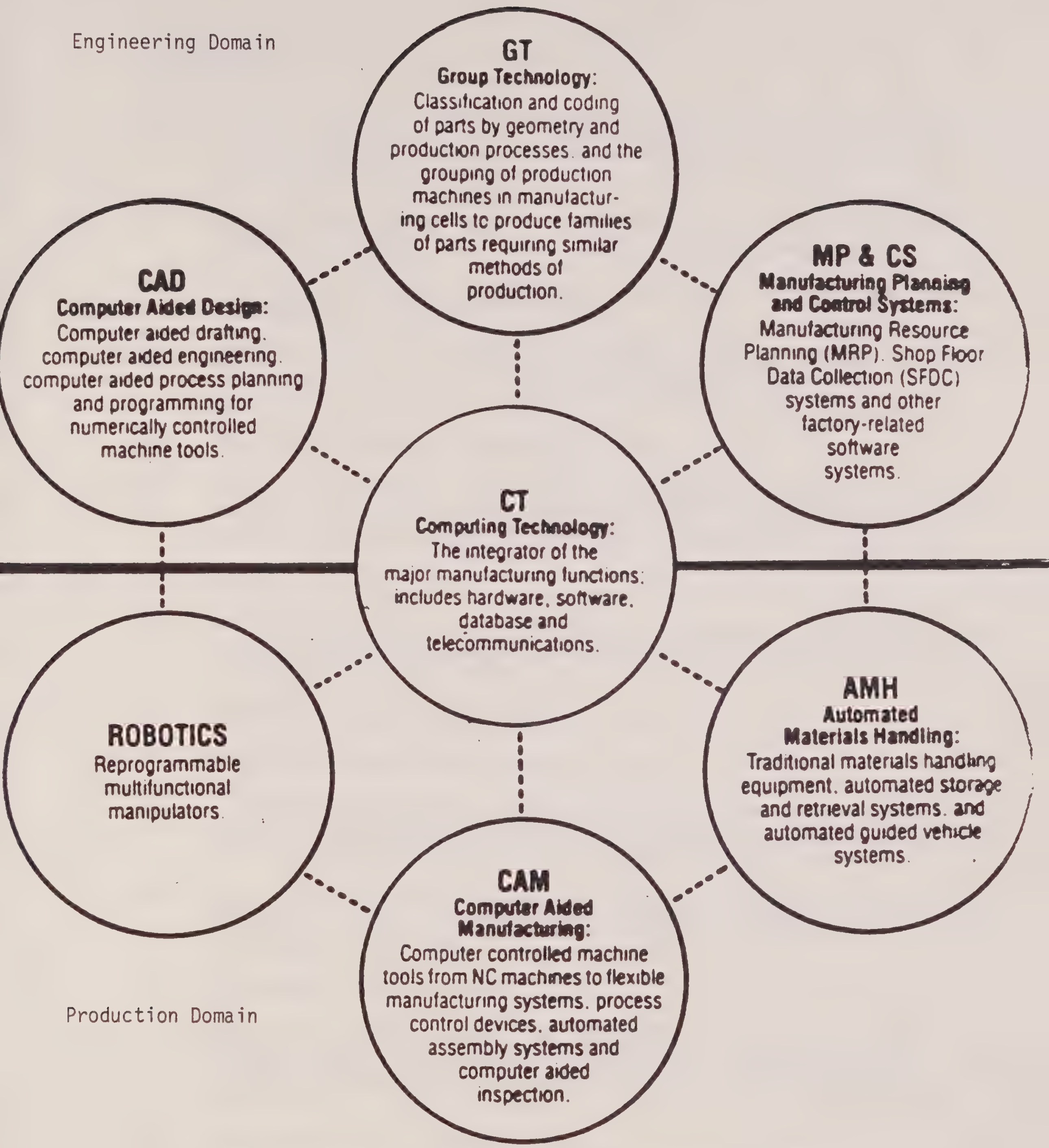
7.0. Summary

As hypothesized in section 5.0, new technology developments and advances in new paradigm organization applications appear to be supportive of each other. This trend towards a new flexible, creative way of working is both appropriate and necessary to remain proactive in a turbulent environment.

Therefore, for Canadian business to survive it must do more than blindly follow the technological road; it must achieve a

tripartite fit between technology, organization and its environment. However, Canadian business must also recognize that future changes in technology may require further changes in organization design to maintain that fit. It is a dynamic relationship, not a one-shot, static design.

EXHIBIT 1



Computer Integrated Manufacturing (CIM)

Source: B. Schlussel, Sperry Inc.

REFERENCES

(1) Fred L. Luconi et al., "Expert Systems: The Next Challenge for Managers," **Sloan Management Review**, vol.27, no. 4 (Summer 1986), p.4-6.

(2) Frank Rose, "The Quest for Thinking Machines," **Science Digest**, vol.94, no.5 (May 1986), p.37-42,84,85,87.

(3) Stephen Strauss, "Then There Was Light," **The Globe and Mail** September 6, 1986, p.E4.

(4) O. Port with J. Wilson and bureau reports, "They're Here: Computers That Think," **Business Week**, January 26, 1987, p.94.

(5) Port with Wilson and bureau reports, p.98.

(6) Peter G. Heytler, "The Delphi Forecast of Trends in Robotics in the United States: 1985 - 1995," Society of **Manufacturing Engineers MM85-675**, 1985, fig.8, p.6.22.

(7) Heytler, p.6.23-6.25.

(8) Words Associated and Keith Newton, **Workable Futures: Notes on Emerging Technologies** (Ottawa: Supply and Services Canada, 1986), p.16-17.

(9) Words Associated and Newton, p.15-17.

(10) Words Associated and Newton, p.31.

(11) G. Betcherman and K. McMullen, **Working with Technology: A Survey of Automation In Canada**, Economic Council of Canada (Ottawa: Supply and Services Canada, 1986), p.31.

(12) Fred Emery, "Tenosynovitis or Repetitive Strain Injuries," December 1984. Available from **Ontario QWL Centre** information service, p.1-6.

(13) Betcherman and McMullen, p.40.

(14) Richard E. Walton and Wendy Vittori, "New Information Technology: Organizational Problem or Opportunity?", **Office: Technology and People**, vol.1, no.4 (May 1983), p.249-273.

(15) Betcherman and McMullen, p.16.

(16) Walton and Vittori, p.249-273.

(17) Daniel E. O'Leary and Efraim Turban, "The Organizational Impact of Expert Systems," **Human Systems Management**, vol.7, no.1 (1987), p.11-19.

(18) Discussions between H. Kerwood, P.Eng. and Dr. H. van Beinum, Executive Director, Ontario QWL Centre, 1987.

BIBLIOGRAPHY

Alfthan, Torkel. "Developing Skills For Technological Change: Some Policy Issues." **International Labour Review**, vol.124, no.5 (September - October 1985).

Argote, Linda, Paul S. Goodman and David Schkade. "The Human Side of Robotics: How Workers React to a Robot." **Sloan Management Review**, vol.24, no.3 (Spring 1983).

Baetz, Mary L., "People/Automation: Good Ways To Get A Mix." **Ernst & Whinney Integrated Office Report**, reprinted from Office Equipment and Methods, October 1985.

Baetz, Mary L. and Suzan Fawcett. "Introducing New Technology: The Human Resource Manager As Facilitator." Human Resources Management in Canada, November 1985, Prentice-Hall Canada Inc. Information Services.

Barret, F.D. "Strategies For The Use of Artificial and Human Intelligence." **Business Quarterly**, vol.51, no.2 (Summer 1986).

Betcherman, G. and K. McMullen. **Working With Technology: A Survey Of Automation In Canada**, Economic Council Of Canada. Ottawa: Supply and Services Canada, 1986.

Beyer, David C. "CAD/CAM Engineering Applications." **IMC Journal**, vol.23, no.1 (January/February 1987).

Boese, Carol. "Better Sooner Than Later." **Access**, May 1986.

Bolwijn, P.T., J. Boorsma, Q.H. van Breskelen, S. Brinkman and T. Kumpe. **Flexible Manufacturing: Integrating Technological and Social Innovation.** Amsterdam: Elsevier Science, 1986.

Bowen, William. "The Puny Payoff From Office Computers." **Fortune**, vol.113, no.11 (May 26, 1986).

Brody, H. et. al. "Japanwatch '86." **High Technology**, vol.6, no.8 (August 1986).

Christiansen, Donald. "Technology '85," **IEEE Spectrum**, vol.22, no.1 (January 1985).

Davis, Dwight B. "Artificial Intelligence Enters the Mainstream." **High Technology**, vol.6, no.7 (July 1986).

Donner, Arthur. "Problem of Job Displacement Is Acute." The **Toronto Star**, November 2, 1986.

Emery, Fred. "Public Policies for Healthy Work-Places." September 1984. Available from **Ontario QWL Centre** information services.

Emery, Fred. "Tenosynovitis or Repetitive Strain Injuries." December 1984. Available from **Ontario QWL Centre** information services.

Heytler, Peter G. "The Delphi Forecast of Trends In Robotics In The United States: 1985-1995." **Society of Manufacturing Engineers MM** 85-675, 1985.

Hoerr, John and Michael A. Pollock with David E. Whiteside. "Management Discovers The Human Side of Automation." **Business Week**, September 29, 1986.

Human Resource Practices for Implementing Advanced Manufacturing Technology. Washington D.C.: National Academy Press, 1986.

Jelinek, Mariann and Joel D. Goldhar. "The Strategic Implications of The Factory of the Future." Sloan **Management Review**, vol.25, no.4 (Summer 1984).

Jurgen, Rik. "Technology '86." **IEEE Spectrum**, vol.23, no.1 (January 1986).

Kao, C. et. al. "10 Views From The Top." **Electronic** Design, vol.33, no.1 (January 10, 1985).

Koepp, S. "The Boss That Never Blinks." **Time**, vol.128, no.4, (July 28, 1986).

Kolodny, H.F. "Trends In The Design of New Manufacturing Facilities." presented at **'The Quality Of Working Life' Seminar**, October 9, 1986.

Kolodny, Harvey F. "Integrating New Technology And The Organization: Governmental Roles." A paper prepared for Technology Canada: **Today's Competitive Weapon-Managing New Technology**, May 21-22,1986, Wilfred Laurier University, Waterloo, Ontario.

Lautenbach, T. "IBM Plans For The Changing World of Telecommunications." **IBM Canada Ltd.**, Customer Information, July/August 1986.

Luconi, Fred L., Thomas W. Malone, and Michael S. Scott Morton. "Expert Systems: The Next Challenge for Managers." **Sloan Management Review**, vol.27, no.4 (Summer 1986).

Mintzberg, Henry. **The Structuring of Organizations**. New Jersey: Prentice-Hall Inc., 1979.

Myerson, Paul and Robert D. Hamilton III. "Matching Corporate Culture and Technology." **SAM Advance Management Journal**, vol.51, no.1 (Winter 1986).

Naisbitt, J. **Megatrends - Ten New Directions Transforming Our Lives**. New York: Warner Books, 1982.

O'Leary, Daniel E. and Efraim Turban. "The Organizational Impact of Expert Systems." **Human Systems Management**, vol.7, no.1 (1987).

Pollock, M.A. and A. Bernstein. "The Disposable Employee Is Becoming A Fact of Corporate Life." **Business Week**, December 15, 1986.

Port, O. with J. Wilson and bureau reports. "They're Here: Computers That Think." **Business Week**, January 26, 1987.

Rose, Frank. "The Quest For Thinking Machines." Science **Digest**, vol.94, no.5 (May 1986).

Roth, J.A. "Trends in Technology: Responding To The Future." **Engineering Digest**, vol.31, no.5 (May 1985).

Schrage, Michael. "Office Workers Beware: Computer-based 'Expert Systems' May Take Over Many of Your Jobs." **The Chronicle - Journal**, Thunder Bay, October 28, 1986.

Skelton, Ron L." The High-Tech Express," **Datamation**, vol.32, no.8 (April 15, 1986).

Skinner, W. "The Productivity Paradox." **Harvard Business Review**, vol.64, no.4 (July-August 1986).

Skinner, Wickham and Kishore Chakraborty. "The Impact of New Technology: People and Organizations In Manufacturing and Allied Industries." **Work In America Institute Studies In Productivity #18**. New York: Pergamon Press, 1982.

Skinner, Wickham and Kishore Chakraborty. "The Impact of New Technology: People and Organizations In Service Industries." **Work In America Institute Studies In Productivity #19**. New York: Pergamon Press, 1982.

Smith, Richard. "Introducing New Technology Into The Office." **Work Research Unit**, London, England, Occasional Paper 20, October 1981.

Strauss, Stephen. "Then There Was Light." **The Globe and Mail**, September 6, 1986.

"Technology, New Products, People Will Restore Leadership of Unimation." **National Productivity Report**, vol.15, no.6 (August 31, 1986). Ed. B. Schleicher.

Texas Instruments Magazine Advertisement. "Artificial Intelligence," 1986, in **High Technology** , vol.6, no.7 (July 1986).

van Beinum, Hans. "The Warp and Weft of QWL - On The Future of the Ontario QWL Centre." **Ontario QWL Centre**, Ontario Ministry Of Labour, October, 1986.

Walton, Richard E. and Wendy Vittori. "New Information Technology: Organizational Problem or Opportunity?" **Office: Technology and People**, vol.1, no.4 (May 1983).

Walton, Richard E. "Social Choice In The Development of Advance Information Technology." Available from **Ontario QWL Centre** information service.

Words Associated and Keith Newton. **Workable Futures: Notes on Emerging Technologies.** (Ottawa: Supply and Services Canada, 1986).